REALIZATION OF ADVANCED SPATIAL INFORMATION SOCIETY BY USING RFID AND GNSS

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ABSTRACT: The Japanese Government executed a new law NSDI (National Spatial Data Infrastructure) for a spatial information society on May 30, 2007. In this law, everybody can know positional information in real time anytime and anywhere. Thus, to realize an advanced spatial information society determined by this law, it should need to obtain positioning information anywhere seamlessly. However, the technology has not been established yet. Our laboratory conducted seamless positioning experiment to verify whether it can obtain position seamlessly by using VRS-GPS (Virtual Reference System-GPS) and passive RFID (Radio Frequency Identification) at an area surrounded by canopies and buildings for realizing an advanced spatial information society. As a result, map on the GIS showed border position of between VRS-GPS and RFID can connect seamlessly. It was confirmed locations where GPS receiver did not receive could complement positioning information by passive RFID.
Next, an experiment was performed near the building by active RFID. An experiment was conducted to verify whether RSSI indicates specific position of RFID tag by changing ATT value. As a result, RSSI by each level of ATT was shown that could narrow down area to receive RFID tag, but could not indicate specific position of it. Therefore, it is difficult to obtain indoor accurate position using only active RFID. We consider that further advanced accuracy of indoor position can obtain by a combination of active RFID and passive sensor. An experiment was performed to verify detecting position of sensor. As a result, it was shown that detectable position was within a radius of 1 meter. Thus, it is possible to obtain accurate position by using active RFID and passive sensor in a building.
We will consider adding QZSS (Quasi-Zenith Satellites System) into our research for advanced spatial information society.

1. INTRODUCTION

Japan is now experiencing an aging society and every a person should be safe and feel relieved. The Japanese Government executed a new law for a spatial information society on May 30, 2007. In this law, everybody can know positional information in real time anytime and anywhere, both of the mappings of a national common base map, and environment for utilizing satellite systems. In addition, it is necessary to keep satellite positioning for realization of seamless positioning, and to promote ubiquitous network technology.
Method of obtaining position has been mainly using GNSS by surveyor and researcher now. Most Japanese surveyor and researcher have been obtaining the position by using GPS which created by the USA. We can obtain high accuracy position by using GPS in open sky, however, position in closed sky cannot obtain accurate position which was caused by multipath and cycle slip.
In additionally, it is necessary to obtain detailed indoor position because many people are also acting in indoor such as underground mall in recent years; however, the technologies have not been established yet. To ensure life of safety, relief and comfort for many people, method of obtaining indoor position should be early established and innovate in the field of geoinfomatics. Other researchers have tried to obtain indoor position by using communication device such as Bluetooth, ultra wideband radio and Wi-Fi (Wireless Fidelity), but it has not developed to a practical level yet.
We focused RFID to obtain indoor position. RFID has already been used in the field of commerce and it is used for electronic money services in country ICT (Information Communication Technology) developing.
Latest indoor and outdoor position using GNSS, RFID and another system must immediately need to update on GIS. When we will get latest and accurate position anytime and anywhere at real time, everyone can live safely.
The purpose of our laboratory is to conduct verification experiment to verify whether RFID can obtain indoor position as a method of complementing indoor position to promote for realizing an advanced spatial information society by enactment of NSDI. Verification experiment is to perform seamless positioning by using passive RFID in the area where GPS signals could not be received to obtain information of absolute positions. And an experiment was

performed based on the assumption that user will obtain the position information in an inside of the building by using active RFID.

2. VERIFICATION EXPERIMENT FOR SEAMLESS POSITIONING BY PASSIVE RFID

To realize an advanced spatial information society, it should need to obtain positioning information anywhere and seamless positioning is indispensable for realization advanced geospatial information society. We conducted seamless positioning to verify whether it can obtain seamless positioning between GPS and RFID on the GIS. GPS was measured in open sky, and RFID tags can complement that GPS receiver could not receive signals from GPS satellites at an area surrounded by canopies and buildings. An experiment was performed inside the KIT campus at Kanazawa district in central Japan. KIT campus has both of open sky and close sky. On the experiment RFID has to write position information into the tag in advance. Therefore, to obtain position information put in tag, we did static positioning by GPS at two positions which include open sky and canopies.
Coordinate which entered tags were obtained by interpolated. Installation intervals of tags are 1.2m because human's walking speed is about 4km/h and GPS data obtains coordinate 1 point at 1 second. Structural elements of experimental machine which include GPS receiver and RFID reader attached to wheelchair are shown in Figure 1. We walked with wheelchair and measured position information around in campus.

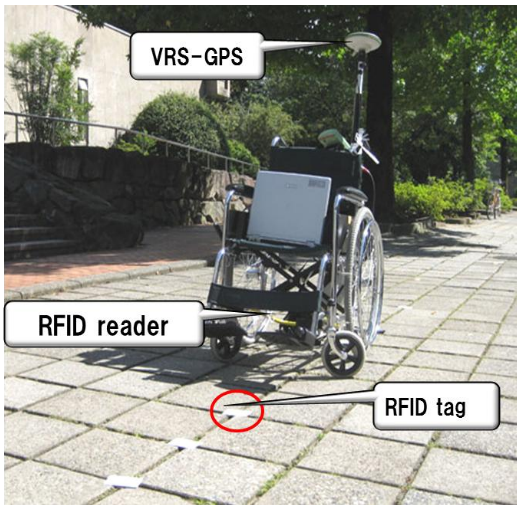

Figure 1 The equipment by experiment

2.1 Equipment

The equipment used is made of Welcat Inc. and specification details are below.

- RFID's reader: EFG-400-01
- An antenna of exclusive RFID's reader writer: ANU-100-01
- RFID tag: card type (ISO15693, 13.56MHz)

2.2 Results and experimental considerations

Figure 2 shows that position of VRS-GPS and passive RFID were overlapped on the aerial photographic map by GIS. Background is air photograph of Kanazawa Institute of technology taken by aircraft. Circle of black and white shows the track obtained by VRS-GPS and passive RFID respectively. It was confirmed locations where GPS receiver did not receive could complement positioning information by passive RFID. Figure 2 indicated that border position can connect seamlessly. It is difficult to obtain a high accuracy positioning around buildings, because large errors arise by cycle slip and multi-path. These effects may avoid by RFID. Positional information were able to obtain seamlessly, however, the experiments had the problem that overlapped track of both is too long as shown in Figure 3.
It is difficult to find position to set the first passive RFID. The number of tag should be decrease to use this principle in a social experiment. Therefore, it was necessary to investigate method to minimize the number of RFID for time and labor. The solution of the problem is to use QZSS (Quasi-Zenith Satellites System). QZSS was launched in 2010 by JAXA and is satellite system taken by a combination of multi orbit plane and each satellite deployed to appear constantly 1 satellite near the zenith in Japan. It is expected to obtain high accuracy position information around the building. Thus, this problem may solve by QZSS.

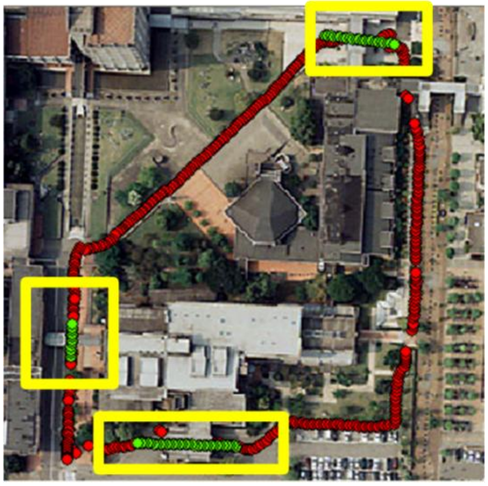

Figure 2　Overlapping display of experimental data

Figure 3　Overlapped track of GPS and RFID

3. VERIFICATION EXPERIMENT FOR SEAMLESS POSITIONING BY ACTIVE RFID

It exists the limit range where tag can be received normally the signal though active RFID has the advantage with long communication distance. As shown in Figure 4, the experimenter with the tag walked toward a reader from a distance position. We investigated whether the reader could be read a tag at any position. However the shielding material was not set between a reader and a tag in the experiment condition.

Figure 4　Experimenter with the tag walked toward a reader from distance position

3.1 Equipment

Equipment was made by KYUSYU TEN Co., Ltd.

【Hardware 】

- Product name: TagStation
  - ・Wi-Fi model faint wireless reader
  - ・Faint wireless writer
  - ・Faint wireless tag
- Wireless Router

（Made by I-O DATA DEVICE .INC.）

【Software 】

- Product name: TagStation
  - ・Location management system
  - ・Setting reader program
  - ・Setting tag program
- Microsoft SQL Server 2005 Express Edition

3.2 Results and considerations

Table 1 shows distance that the reader read position of the farthest tag. This experiment was repeated 7 times and the distance average is 12m .As a results, maximum reader range is 12m. Thus, setting intervals of reader is advisable to set radius 12m intervals in using many readers at wide area.

Table 1　Distance that the reader read position of the farthest tag

Times	1	2	3	4	5	6	7
Walking speed [m/s]	1.20	1.25	1.20	1.20	1.20	1.25	1.15
Distance [m]	10	14	11	11	14	14	10

3.3 Relationship between RSSI, ATT and distance

Active RFID can confirm value of RSSI and ATT by recording data of viewer. RSSI means a sensitivity of tag receiver, and it changes from interval of receiver distance. ATT is attenuator and signal of it is classified into 3 types which are high, medium and naught. An experiment was conducted to verify whether RSSI indicates concrete interval. ATT values of RSSI were investigated when the examinee moves away from reader every 50 cm (Figure 5).

Figure 5 Experimental outline of RSSI and ATT

3.4 Results and considerations

Table 2 shows the relationship between RSSI and ATT as maximum range with high, medium and naught of ATT. RSSI by each level of ATT were almost no change regardless of received range. Maximum received range 12.5m and farther range could not receive information of tag. The change of range by ATT and specific range by RSSI could not confirm in the experiment. However, receiving range of RSSI will be able to roughly estimate position of tag.

Table 2 RSSI and maximum range

RSSI	ATT			received range
	high	medium	naught	
	Received range[m]			[m]
10		-	0.0	0.0
9	0.5～1.0	-	1.0	1.0
8	0.0～5.5	0.0-4.5	0.5～5.5	5.5
7	2.0～6.0	-	2.5～6.5	6.5
6	8.0	5.0-8.0	6.0～7.5	8.0
5	6.5	6.5	8.0～8.5	8.5
4	7.0～11.5	7.0～11.0	7.0～11.0	11.5
3	12.5	9.5～12.0	9.5～12.5	12.5

4. VERIFICATION EXPERIMENT BY SENSOR

A chapter 4 shows that only use of an active RFID could not possible to obtain the accurate position information. Therefore we consider obtaining more accurate position information by using both of active RFID and passive sensors. The sensors receive the signal from objects within 1.5~3m radius. Further high accuracy of indoor position information can obtain by a combination of active RFID and passive sensor is to utilize the advantage of both sensors.
Then seamless positioning from indoor to outdoor will be able to do accurately by a collaboration of geoinfomatics technology.

4.1 Equipment

Equipment was made by TAKENAKA ENGINEERING Co., Ltd.
Passive sensor: PA-6705
Power-supply device: switching AC adapter (9V)
Electrical cable: AWG22 (0.3mm2)
The feature of sensor is to detect human and object with heat by infrared ray. It is connected to RFID reader and transmits signal to reader.

4.2 Experiment

Confirmatory experiment was conducted whether a passive sensor detected examinee on any position in a room. An examinee entered detecting area of sensor from X and Y direction as shown in Figure 6 ,and he or she repeated 100 times this action for each direction. X direction shows front side of sensor. Examinee's walking speed is 3 levels which was normal walk, brisk walk and run. We assumed speeds which person generally walks inside a room.

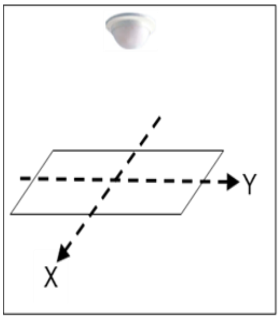

Figure 6 Experimental outline of RSSI and ATT

4.3 Results and considerations

Table 3 shows average and standard deviation of detecting position that examinee entered detecting area of sensor for each direction. As a result, all detected position of sensor was within a 1m radius, regardless of walk speed. Thus, combination of active RFID and passive sensor is better than that of single use. Researcher who applies tag and RFID to people can obtain accuracy position by using the idea.

Table 3 Detecting position from X and Y direction

		average	standard deviation
Normal walk	X	13.24	8.8960
	Y	62.89	13.1775
Brisk walk	X	30.23	10.7477
	Y	99.78	9.5787
Run	X	5.68	6.4107
	Y	63.02	15.7601

Unit: [cm]

5. CONCLUSION

Establishment of NSDI gave us to chance to promote of advanced geospatial information society, and an experiment was conducted by using passive and active RFID. Chapter 3 shows seamless positioning was conducted by GPS and passive RFID. As a result, it is possible to do indoor positioning by setting passive RFID. Thus, combination of GPS and passive RFID is useful tool for seamless positioning. However, the part where tracks of the GPS overlapped with tracks of the RFID existed. The number of tag should be decrease to use this principle in a social experiment. Therefore, it was necessary to investigate method to minimize the track of GPS and RFID overlapping to minimize time and labor. The solution of the problem is to use QZSS. It is expected to obtain high accuracy position information around the building, and the problem may solve by QZSS. Then seamless positioning from indoor to outdoor will be able to do accurately by a collaboration of geoinfomatics technology.
A chapter 4 shows experiment was conducted by Active RFID to obtain indoor position. As a result, it cannot obtain the exact location by using active RFID only. Therefore we consider obtaining more accurate position information by using both of active RFID and passive sensors. Verification experiment was performed whether a passive sensor detected examinee on any position in a room. As an analysis, sensor's detection area was within a 1m radius regardless of walk speed. Thus, combination of active RFID and passive sensor is better than that of single use. It is possible to obtain high accuracy indoor position, and it will reduce the cost of the system using the method suggested by us.
We hope to achieve advanced spatial information society which can easily obtain indoor and outdoor position anytime and anywhere as shown in the Figure 7 in near future.

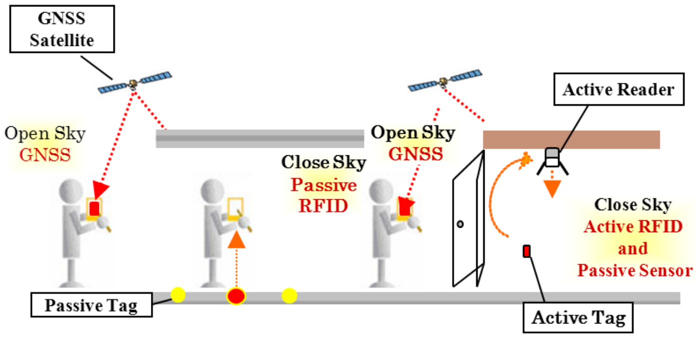

Figure 7 Concept of Seamless positioning experiment

6. FUTURE VIEW

We will conduct experiment for realizing an advanced spatial information society in the future. As described a chapter 3, QZSS was launched in 2010 by JAXA and is satellite system taken by a combination of multi orbit plane and each satellite deployed to appear constantly 1 satellite near the zenith in Japan. Japan and other neighboring countries will be able to receive signals from QZSS anytime and anywhere when 3 satellites of QZSS will be launched. However QZSS was launched only 1 satellite and it is confined that area where can receive signals from QZSS now. Therefore, it is using for the purpose of demonstration experiment in Japan. We are joining this experiment and be taking the demonstration experiment of a part of Hokuriku area in Japan. If the experiment is successful, positions will obtain at an area surrounded by canopies and buildings without affecting by cycle slip and multi-path.

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